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THE FOURTH CONFERENCE OF THE INTERNATIONAL UNION FOR CO-OPERATION
IN SOLAR RESEARCH.

By H. C. WILSON.

This conference, held at the Mount Wilson Solar Observatory from August 29th to September 3d, 1910, was remarkable for the number and representative character of the delegates in attendance. Thirteen different countries and fifty different observatories and laboratories, where work is carried on in connection with the study of the Sun, were represented. The following is the official list of the members of the conference:—

Mr. CHARLES G. ABBOT,	Smithsonian Astrophysical Observatory,	Washington, D. C.
Mr. WALTER S. ADAMS,	Mt. Wilson Solar Observatory.	
Prof. J. S. AMES,	Johns Hopkins University,	Baltimore, Md.
Mr. HAROLD D. BABCOCK,	Mt. Wilson Solar Observatory.	
Prof. J. O. BACKLUND,	Observatoire de Poulkovo,	Poulkovo, Russia.
Prof. E. E. BARNARD,	Yerkes Observatory,	Williams Bay, Wis.
Prof. A. BELOPOLSKY,	Observatoire de Poulkovo,	Poulkovo, Russia.
M. JEAN BOSLER,	Observatoire de Meudon,	Meudon, France.
Prof. F. P. BRACKETT,	Pomona College,	Claremont, Cal.
Miss CORA G. BURWELL,	Mt. Wilson Solar Observatory.	
Prof. W. W. CAMPBELL,	Lick Observatory,	Mount Hamilton, Cal.
Prof. C. A. CHANT,	University of Toronto,	Toronto, Canada.
M. HENRI CHRETIEN,	Observatoire de Nice,	Nice, France.
Rev. P. R. CIRERA, S. J.,	Observatorio del Ebro,	Tortosa, Spain.
Dr. W. W. COBLENTZ,	Bureau of Standards,	Washington, D. C.
Rev. A. L. CORTIE, S. J.,	Stonyhurst College Observatory,	Lancashire, England.
M. A. COTTON,	Ecole Normale Superieure,	Paris, France.
M. H. DESLANDRES,	Observatoire de Meudon,	Meudon, France.
Prof. N. DONITCH,	Observatoire de l'Universite,	St. Petersburg, Russia.
Mr. FRANK L. DREW,	Mt. Wilson Solar Observatory.	
Prof. F. W. DYSON,	Royal Observatory,	Edinburgh, Scotland.
Mr. FERDINAND ELLERMAN,	Mt. Wilson Solar Observatory.	
Dr. P. EVERSHEIM,	University of Bonn,	Bonn, Germany.
Prof. CHARLES FABRY,	Universite de Marseilles,	Marseilles, France.
Dr. EDWARD A. FATH,	Mt. Wilson Solar Observatory.	
Mrs. W. P. FLEMING,	Harvard College Observatory,	Cambridge, Mass.
Mr. F. E. FOWLE,	Smithsonian Astrophysical Observatory,	Washington, D. C.
Prof. A. FOWLER,	Imperial College of Science and Technology,	South Kensington, London, England.
Prof. PHILIP FOX,	Dearborn Observatory,	Evanston, Ill.
Prof. E. B. FROST,	Yerkes Observatory,	Williams Bay, Wis.
Dr. HENRY G. GALE,	University of Chicago,	Chicago, Ill.
Prof. L. H. GILMORE,	Throop Polytechnic Institute,	Pasadena, Cal.
Miss CLEMENTINA D. GRIF- FIN,	Mt. Wilson Solar Observatory.	

- Prof. GEORGE E. HALE, Mt. Wilson Solar Observatory.
 M. M. HAMY, Observatoire de Paris, Paris, France.
 Prof. J. HARTMANN, Koenigliche Sternwarte, Goettingen, Germany.
 Prof. K. HAUSSMANN, Technische Hochschule, Aachen, Germany.
 Prof. J. v. HEPFERGER, Imperial Observatory, Vienna, Austria.
 Major E. H. HILLS, 33 Prince's Garden, London, England.
 Prof. W. J. HUMPHREYS, U. S. Weather Bureau, Washington, D. C.
 M. IDRAC, Observatoire de Meudon, Meudon, France.
 Prof. J. C. KAPTEYN, Astronomical Laboratory, Groningen, Holland.
 Prof. H. KAYSER, University of Bonn, Bonn, Germany.
 Dr. ARTHUR S. KING, Mt. Wilson Solar Observatory.
 Prof. H. KONEN, Physikalisches Institut, Muenster, Germany.
 Prof. F. KUESTNER, Koenigliche Sternwarte, Bonn, Germany.
 Mr. C. O. LAMPLAND, Lowell Observatory, Flagstaff, Ariz.
 Sir JOSEPH LARMOR, Royal Society, London, England.
 Miss Jennie B. LASBY, Mt. Wilson Solar Observatory.
 Prof. A. O. LEUSCHNER, University of California, Berkeley, Cal.
 Prof. H. C. LORD, Emerson McMillin Observatory, Columbus, Ohio.
 Dr. JAMES D. MADDRILL, International Latitude Observa-
 tory, Ukiah, Cal.
 Prof. A. G. MCADIE, U. S. Weather Bureau, San Francisco, Cal.
 Prof. E. MILLER, University of Kansas, Lawrence, Kan.
 Dr. WALTER M. MITCHELL, Detroit Observatory, Ann Arbor, Mich.
 Prof. H. F. NEWALL, University Observatory, Cambridge, England.
 Mr. F. G. PEASE, Mt. Wilson Solar Observatory.
 Prof. E. C. PICKERING, Harvard College Observatory, Cambridge, Mass.
 J. S. PLASKETT, Esq., Dominion Observatory, Ottawa, Canada.
 Comte A. DE LA BAUME
 PLUVINEL, 7 Rue de la Baume, Paris, France.
 Prof. E. PRINGSHEIM, University of Breslau, Breslau, Germany.
 Prof. P. PUISEUX, Observatoire de Paris, Paris, France.
 Prof. A. RICCO, Osservatorio astrofisico, Catania, Sicily.
 Prof. G. W. RITCHEY, Mt. Wilson Solar Observatory.
 Prof. A. L. ROTCH, Blue Hill Observatory, Hyde Park, Mass.
 Dr. HENRY NORRIS RUSSELL, Princeton University, Princeton, N. J.
 Prof. J. R. RYDBERG, University of Lund, Lund, Sweden.
 Dr. CHARLES E. ST. JOHN, Mt. Wilson Solar Observatory.
 Prof. FERNANDO SANFORD, Leland Stanford Jr. University, Palo Alto, Cal.
 Dr. FRANK SCHLESINGER, Allegheny Observatory, Allegheny, Pa.
 Prof. ARTHUR SCHUSTER, Victoria Park, Manchester, England.
 Prof. K. SCHWARZSCHILD, Astrophysikalisches Observa-
 torium, Potsdam, Germany.
 Prof. F. H. SEARES, Mt. Wilson Solar Observatory.
 Dr. V. M. SLIPHER, Lowell Observatory, Flagstaff, Ariz.
 Prof. FREDERICK SLOCUM, Yerkes Observatory, Williams Bay, Wis.
 Miss RUTH E. SMITH, Mt. Wilson Solar Observatory.
 Prof. S. W. STRATTON, Bureau of Standards, Washington, D. C.
 Prof. H. STRUVE, Koenigliche Sternwarte, Berlin, Germany.
 Prof. W. L. TOWER, University of Chicago, Chicago, Ill.
 Prof. S. D. TOWNLEY, Leland Stanford Jr. University, Palo Alto, Cal.
 Prof. H. H. TURNER, University Observatory, Oxford, England.
 Miss LOUISE WARE, Mt. Wilson Solar Observatory.
 Miss PHOEBE WATERMAN, Mt. Wilson Solar Observatory.
 Prof. F. R. WATSON, University of Illinois, Champaign, Ill.
 Prof. H. C. WILSON, Goodsell Observatory, Northfield, Minn.
 Prof. A. WOLFER, Sternwarte des Eidgenoss-
 ischen Polytechnikums, Zurich, Switzerland.

The members gathered at the headquarters, the Hotel Maryland, in Pasadena, California, on Sunday afternoon and Monday morning. The first day was spent in examining the Pasadena offices, machine- and instruments-shops, and physical laboratory of the Solar Observatory. From four to six in the afternoon a garden party was given at the home of Dr. and Mrs. HALE. Tuesday was occupied by the ascent of the mountain, which was accomplished in various ways by the different members—in carriages, on foot, and by saddle-horse.

All the formal sessions were held at the summit of Mount Wilson, in the museum, a one-story wooden building, with a second roof of white canvas, which kept the building quite cool and comfortable even in the hottest part of the day.

The first session was called to order at 9:30 A. M. on Wednesday by Professor ARTHUR SCHUSTER, chairman of the Executive Committee. Professor E. C. PICKERING was chosen as presiding officer for the first day, Professor W. W. CAMPBELL for Thursday, and Professor E. B. FROST for Friday. Messrs. WALTER S. ADAMS of the Solar Observatory, P. PUISEUX of Paris, H. KONEN of Muenster, and HAROLD D. BABCOCK of the Solar Observatory were elected secretaries of the conference.

Professor GEO. E. HALE gave the address of welcome. He said that the most important work of the Union was the stimulation of research, and the meetings at Oxford and Paris had been of use in this way. It was a question, perhaps, whether formal co-operation would be a success. One thing which had been accomplished was the establishment of secondary standards of wave-length. He spoke of the need for tertiary standards, and said that the spectrograms taken with the tower telescope were well adapted to the measurement of such standards. For the study of the spectra of sun-spots and the Zeeman effect a map of the spot spectrum is required on a large scale. Dr. HALE suggested one centimeter to one Ångström unit, and asked the question whether a map on such a scale could be prepared and what would be the practicable length of the sections of the map. He spoke of the tower telescope and said that it was designed especially to meet the conditions on Mount Wilson. It might not be adapted to use in other localities. The arrangement of the collimating lens, grating, and mirrors at the bottom of the 80-foot well and of

the slit and plateholder at the surface was described with the aid of diagrams rapidly sketched on the blackboard.

Photographs of the Sun can be obtained from both edges of the $H\alpha$ (red hydrogen) line simultaneously by using two mirrors and two slits. Such photographs often differ very much from each other, the one showing the effect of descending, the other, of ascending, currents of hydrogen.

In the spectra of sun-spots certain lines are double and others are triple. The same lines are always affected in the same way in different spots. The iron line at $\lambda 6303$ is triple, sometimes wide, sometimes less separated. To show this requires high resolving power and extremely high dispersion. Experiments in the laboratory show that doubling, tripling, and even higher multiplication of metallic lines is produced by passing the light through a powerful electro-magnetic field. In a spot spectrum the components of some lines may be parallel and those of others may be convergent at the same time, showing differences of the electric field at different levels. It is possible from these differences to determine the direction of the axis of a vortex about a sun-spot.

Professor HALE explained a device by means of which, with several slits close together, he photographs the spectra of different portions of the same spot on the same plate at once, and thus is enabled to determine the direction of the lines of force around the spot.

In conclusion, he said that work with the $H\alpha$ line was much more important than with the calcium lines for the study of eruptive phenomena.

The report of the Executive Committee was then given by Professor SCHUSTER, and the report of the committee on wave-lengths by Professor KAYSER. The latter report was perhaps the most important of those made at the conference, in that it presented for adoption a table of 371 standard wave-lengths, mostly of the iron arc spectrum. This table will be published in the October number of the *Astrophysical Journal*. Professor KAYSER spoke of the fact that MICHELSON's determination, by the interferometer method, of the wave-length of the red Cadmium line at $\lambda 6438$ had been adopted at a former conference as the primary standard. Progress has been made on the wave-lengths of iron by Messrs. FABRY and BUISSON at Paris,

EVERSHEIM at Bonn, and PFUND at the Johns Hopkins University. The results obtained by these three agree very closely, the differences from the mean of the three rarely amounting to more than .002 or .003 of an Ångström unit.

The following recommendations presented by the committee were adopted after a short debate and after each recommendation had been read in turn in English, French, and German:—

RECOMMENDATIONS OF THE COMMITTEE ON WAVE-LENGTHS.

1. In the region of the spectrum in which three independent measurements by the interferometer method of the lines of the iron arc are available, i. e. between $\lambda 4282$ and $\lambda 6494$, the arithmetical mean of the three measurements shall be adopted as definite international standards of second order, provided there is sufficient agreement between them.
2. The committee to be given authority to publish these standards as soon as possible.
3. For the part of the spectrum in the neighborhood of $\lambda 5800$, where the number and character of the iron lines are not satisfactory, the committee proposes the use of barium lines as additional standards.
4. Laboratories or observatories possessing first-rate concave gratings are invited to determine by interpolation as soon as possible standards of the third order in the spectrum of the iron arc within the above region (i. e. $\lambda 4282$ to $\lambda 6494$).
5. The measurement of standards of the second order shall be extended to shorter and longer wave-lengths, and the arithmetical mean of three independent determinations shall be adopted as secondary standards.
6. Standards of the third order shall then be obtained in the manner indicated.
7. The above system of standards shall be called the International System, the unit on which it is based being called the International unit (I. A.), as defined by the conference of 1907.
8. It is desirable that in different laboratories possessing concave gratings of the first quality photographs of arc, spark, and solar spectra, and new measurements according to the international system shall be taken as soon as possible.

On Wednesday evening an address was given by Mr. C. G. ABBOT, director of the Smithsonian Astrophysical Observatory, in which he gave a brief historical outline of the study of solar radiation. The most probable value of the solar constant of radiation appears now to be about 1.92 calories per square centimeter per minute. From the last few years work at the Smithsonian Observatory at Washington and Mount Wilson, there are fairly strong indications of frequent variability of

the order of five or ten per cent in the intensity of the solar radiation outside the Earth's atmosphere, and there are also indications from the study of a longer interval that there is a periodic variation coinciding in time with that of sun-spot frequency, the maximum radiation accompanying the sun-spot minimum.

At the second session, Thursday morning, invitations were extended to the members of the conference to visit Lick Observatory, Leland Stanford Jr. University, and the University of California.

The report on the measurement of solar radiation was presented by Mr. C. G. ABBOT. As the committee had held no meeting, there being only two of the members present, the report could not be considered an official report of the committee, but it was accepted for record.

Professor FOWLER spoke of the fact that papers and photographs forwarded by Professor CALLENDAR had failed to arrive.

Professor HUMPHREYS described a new type of pyrheliometer designed by Mr. MARVIN of the Weather Bureau. It is of the electrical resistance type, the principal part being a coil of very thin nickel ribbon. Its resistance is independent of the portion of the coil upon which the heat falls. Several such instruments are now in use and the results are entirely in accord with those obtained by the Abbot secondary pyrheliometer.

Professor SCHWARZSCHILD spoke of the work of Messrs. MÜLLER and KRON at Alta Vista, on the peak of Mount Teneriffe. Their results agree exceedingly well with those of Mr. ABBOT.

Professor SCHUSTER said that it was desirable to study the variation of intensity of the solar radiation from different parts of the disk. The photosphere and absorbing layer are not separate and the effect from the two is not the same near the limb as near the center of the disk. One problem can be treated mathematically and that is where the heat is given out by radiation only—neglecting convection. On this supposition, calculating the absorption of air which we should expect if there were no other agency than pure air, the result for the solar radiation agrees with that obtained by ABBOT.

Professor PICKERING spoke of the possibility of observations of solar radiation being made at Arequipa if instruments could be furnished, and offered the use of the Harvard station and observers for that purpose.

In reply to the question whether a pyrheliometer of approved type would be sufficient for this work or would bolometric observations be required, Mr. ABBOT said that either many pyrheliometers might be employed at different stations or there should be at least one bolometric station aside from that of the Smithsonian Observatory. If any one would guarantee him \$4,000 a year he would go to southern Mexico and make the observations.

Professor FOWLER presented the report of the committee on sun-spot observations, showing that six observers are now co-operating in the work of obtaining observations of spot spectra. One notable result is that the spot spectrum is found to be as constant as the Fraunhofer spectrum. Its study is therefore less interesting than was expected. The following resolutions were presented and adopted:—

1. That the reports of the Solar Committee and of the co-operating observers be printed in the *Transactions* of the Union in full or in abstract as circumstances may determine.
2. That notwithstanding the photographic results, visual observations are desirable and the committee should be continued.
3. That the committee be requested to prepare and circulate a revised scheme of observations.
4. In view of the fact that several observers have prepared catalogues of great numbers of sun-spot lines, it is desirable that these results be collated.
5. It is desirable that the sections of the new map of the sun-spot spectrum do not exceed sixty centimeters in length and be on a scale of five millimeters to one Ångström.

Professor NEWALL spoke of the possibility of using plane gratings for measuring wave-lengths of tertiary standard lines.

Mr. ADAMS spoke of the use of plane gratings in measuring solar rotation at Mount Wilson, and said that for a long distance in the spectrum the reduction factors follow a straight line. Experience shows that the results are extremely accurate, the accidental errors for the arc lines averaging only 0.0014 Ångström units and for the enhanced lines in the solar spectrum only 0.0020 Å.

Professor FABRY said that for short spaces of the spectrum plane gratings may be even better than concave gratings.

Dr. ST. JOHN emphasized the accuracy obtained with plane gratings, for short distances with sufficient standards between.

The report of the eclipse committee, in the absence of the chairman, Sir NORMAN LOCKYER, was presented by the secretary, Count A. DE LA BAUME PLUVINEL.

Some little debate occurred over the one recommendation of the committee, that angles of position around the Sun's limb be recorded from north toward east, but the recommendation was finally adopted.

Major HILLS spoke of the advisability of the committee keeping in close touch with other committees in regard to preparations for observing eclipses.

Professor DONITCH spoke of the desirability of co-operation in observations of the chromospheric spectrum.

Professor CAMPBELL described a method of using a moving plateholder for photographing the flash spectrum, as applied by him in recent eclipses.

On Thursday evening Professor KAPTEYN gave an extremely interesting address on "Star Streams," of which it is impossible to give any adequate account here, but which will be published in full in the *Transactions* of the Solar Union.

From a study of the proper motions, according to Boss's catalogue, of the stars of the *Orion* or *B* spectral type he found that all of these stars in a large region of the sky, containing the constellations *Scorpio* and *Centaurus*, were moving in nearly the same direction and at nearly the same rate. This region covers 4,500 square degrees, extending roughly from $12^{\text{h}} 0^{\text{m}}$ to $18^{\text{h}} 0^{\text{m}}$ in right ascension and from 0° to -60° in declination. In another region, of 1,300 square degrees around the constellation *Perseus*, from $2^{\text{h}} 50^{\text{m}}$ to $4^{\text{h}} 30^{\text{m}}$ in right ascension and from $+15^{\circ}$ to $+55^{\circ}$ in declination, all the stars of the same type were found to be moving in a different direction. Professor KAPTEYN finds that these apparent motions may be explained on the supposition of two star streams moving in exactly opposite directions at equal rates, their apparent motions being the resultants of their real motions combined with that of the Sun, so that the average apparent velocity in the line of sight of the stars of one group comes out about

twenty-eight kilometers per second, while that of the other is about eighteen kilometers. Professor KAPTEYN said that he was led to take up this investigation by finding a discrepancy of about nine kilometers in the velocity of the solar system as determined from the known radial velocities of the *Orion* type stars near the apex of the solar motion and from those near the antapex or opposite point of the heavens. He finds that these stars are very distant from the Sun, the theoretical parallax ranging from $0''.006$ to $0''.026$. On examining the proper motions of stars of other spectral types in the same regions of the sky, he finds that all of those which possess similar motions are of the *A* type, which is next in order of probable development to the *B* type.

At the third session, Friday morning, the report of the committee on the determination of solar rotation by the displacement of lines was presented by Mr. ADAMS. A resolution offered by Professor NEWALL was adopted, that the committee be reappointed with power to initiate and continue the plan of co-operation proposed at its first meeting.

M. DESLANDRES proposed to add to the field of work of the committee the study of the movements of the solar atmosphere, and therefore to change the name of the committee to that of "the committee on the study of solar motions," but this did not find favor.

Mr. ABBOT suggested that, as the lines of heavy elements disappear at the Sun's limb, measures of these lines might be taken at such distances from the limb as are practicable.

M. DESLANDRES reported on the work of M. PEROT of Meudon, and advocated the method of photographing the surface of the Sun in sections in the light of one particular portion of the spectrum. This method has the advantage that the edges of the limiting slit near the photographic plate serve as reference lines for measuring relative radial velocities all over the solar disk. The limiting slit may be one or two millimeters wide, with a particular line (*K* for instance) in the middle of the slit.

The report of the committee on the spectroheliograph was presented by Professor FROST in the absence of Professor HALE. It included a report from Father CIRERA of Tortosa, Spain, on the classification of faculæ; a report from Professor

Ricco of Catania, Sicily, showing that since 1908 the photosphere has been photographed on 418 days and the chromosphere on 366 days; and a report from Yerkes Observatory of over four thousand plates obtained with the spectroheliograph since 1904.

The resolutions offered by the committee and adopted by the conference were in substance as follows:—

1. That daily photographs of calcium flocculi be continued.
2. That provision be made for the measurement of the photographs.
3. That the Japanese Government be approached in regard to the establishment of a solar observatory in Japan.
4. That the observatories of Tacubaya, Mexico, and Madrid, Spain, be added to the list of co-operating observatories.
5. That the committee recognize the advisability of the use of spectroheliographs of high dispersion.
6. That the fund raised in Italy as a memorial of Father SECCHI be devoted to the construction of a tower telescope.

On Friday afternoon the question as to whether the Solar Union should take up the study of stellar spectra was made the special topic of the first hour. Although there appeared to be general hesitation to make a definite proposition, it was soon found from an informal discussion that all were agreed upon the subject and it was formally voted—

That the Solar Union extend its activity so as to include general astrophysics, and that a committee be appointed to consider and report on the question of the classification of stellar spectra.

The committee appointed later consists of Professors PICKERING (chairman), SCHLESINGER (secretary), ADAMS, CAMPBELL, FROST, HALE, HAMY, HARTMANN, KAPTEYN, NEWALL, PLASKETT, and SCHWARZSCHILD.

Professor PICKERING explained the origin of the Harvard system of classification, saying that it was merely alphabetical at first and that afterwards it seemed best to drop some of the letters and change the order. It has now simmered down to fundamentally six types, designated *B*, *A*, *F*, *G*, *K*, and *M*, which may perhaps express a certain order in the evolution of stars. It would be extremely undesirable to introduce a new system until we know more certainly the true order of stellar evolution as indicated by their spectra, and it is to be hoped that no radical action will be taken.

Professor SCHUSTER said there is no danger that this committee will take any premature action. No one expects it to present at the next meeting any scheme of classification, but only to collect and present various opinions.

The following resolution was adopted:—

This conference learns with pleasure that it is proposed to erect a solar observatory in Japan.

For the meeting-place of the next conference invitations were presented from Bonn, Germany; Barcelona, Spain, and Rome, Italy. Professors KAYSER and KÜSTNER presented the claims of Bonn, Father CIRERA spoke in behalf of Barcelona, and Professor RICCO for Rome. It was voted that the meeting of the Solar Union of 1913 be held at Bonn, and that the time of meeting be fixed by the Executive Committee in consultation with Professors KAYSER and KÜSTNER.

The remainder of the session was taken up with the appointment of the various committees and votes of thanks to Professor and Mrs. HALE and the members of the observatory staff who had part in making the meeting so great a success.

Saturday morning was occupied with the descent from the mountain, and on Saturday evening the banquet given to the members of the conference at the Hotel Maryland by Professor and Mrs. HALE, at which about one hundred guests were seated, brought to a fitting close a memorable meeting.
